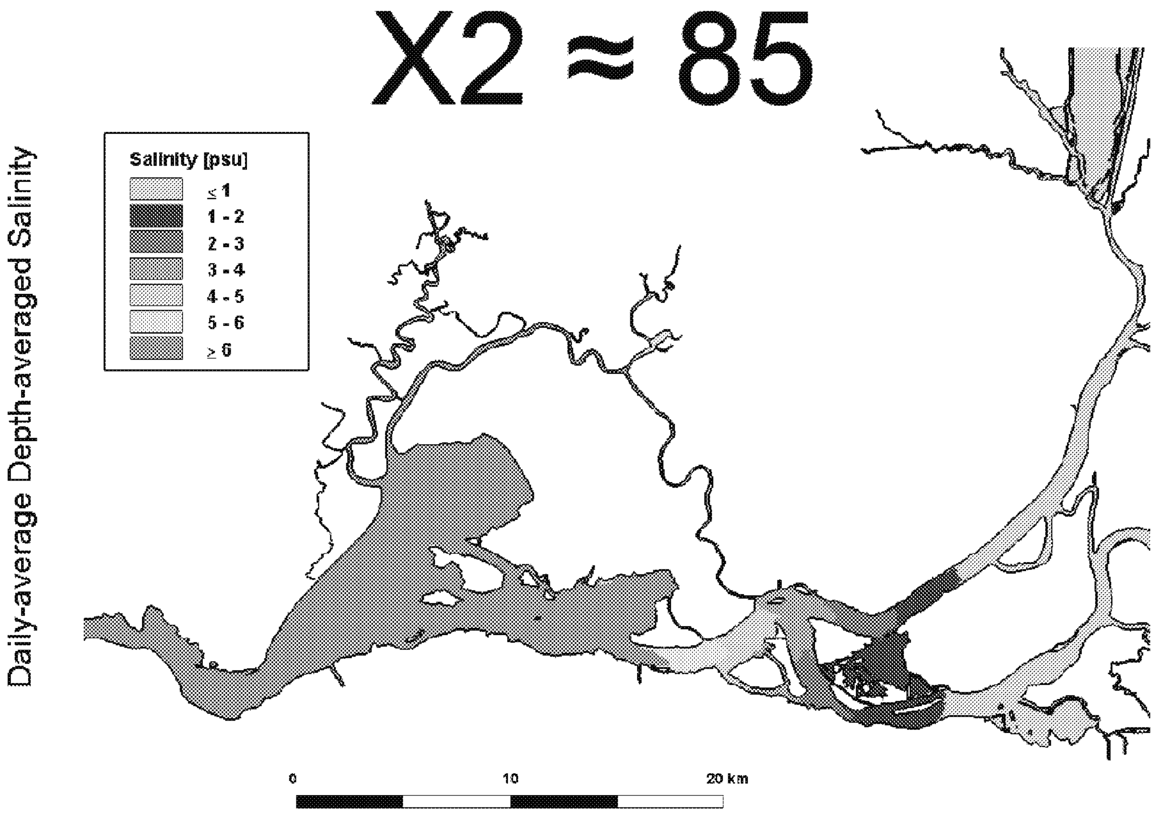

Figure 9.2.3.3.3-10. Daily-averaged depth-average salinity in psu (practical salinity units) between Carquinez Strait and the western Delta for X2 located at 85 km (Delta Modeling Associates 2012).

An additional consequence of the upstream encroachment of X2 by the operational scenario in the PA is increased salinity in the western part of designated critical habitat (approximately 10%), as suggested by the DSM2-QUAL modeling in Montezuma Slough for August and September. This projected salinity increase would further degrade juvenile rearing critical habitat for delta smelt. The preferred salinity range for delta smelt is between about 0.5 and 6 ppt (Kimmerer 2004; Komoroske *et al.* 2016). Delta smelt can tolerate higher salinities, but increased osmoregulation comes at an energetic cost that is highly undesirable to a food-limited fish (Hammock *et al.* 2016; Slater and Baxter 2014). In Montezuma Slough at National Steel in eastern Suisun Marsh, salinity in August is currently above 6 ppt 10% of the time. Under the operational scenario in the PA, salinity would exceed 6 ppt 20% of the time. In September, salinity conditions favorable for smelt would be projected to decrease in frequency from 50% of the time to 40% of the time (CWF BA 2016, Table 5.B.5-28). Thus, the operational scenario in the PA would result in favorable salinity for rearing in Montezuma Slough at National Steel in only wet and above normal years. Further west in Montezuma Slough at Beldon's Landing in north-central Suisun Marsh, favorable salinity conditions in August would occur only 40% of the time and only during wet and above normal years (CWF BA 2016, Table 5.B.5-27). September salinity conditions would be favorable 30% of the time and only in wet years. Salinity in Montezuma Slough would improve in October and November, but this improvement in designated critical habitat quality could only be realized by fish that survive through August and September. Suisun Marsh, including Montezuma Slough, is high quality habitat for delta smelt, because here these fish exhibit better condition and growth, reduced contaminant exposure (Hammock *et al.* 2015), and no risk of entrainment into the CVP and SWP.

During the months of December through June, additional protections may be implemented during RTO to protect pulses of out-migrating salmonids in the mainstem of the Sacramento River, which will result in a reduction in water exports at the NDD (refer to the revised May 5, 2017 *BiOp Resolution Log*). CalSim II and the subsequent step-down analyses did not model these changes in future decisions because they are based on RTO which is based on fish presence which are unknown at this time. During RTO, there is a potential for there to be a shift in exports between the NDD and south Delta that could increase south Delta water exports in such a way that would change the location and suitability of the rearing habitat at the LSZ. Subsequent consultations will occur as they relate to those CWF activities subject to future Federal approvals, such as the dual conveyance operations, in which Reclamation and DWR have committed to analyze and further address species effects from CWF operations at that time (refer to the *Consultation Approach* section of this BiOp). In addition, implementation of Guiding Principles 1 and 2, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, will ensure that future development of CWF operational criteria will improve habitat conditions for rearing juvenile delta smelt. These Guiding Principles are anticipated to minimize adverse effects of CWF to rearing habitat in delta smelt designated critical habitat.

9.2.3.3.4 Adult Migration Habitat

PCE 1 – Physical Habitat

Delta smelt require specific in-water substrates only for spawning, but depth variation is helpful for small fish migrating upstream against net downstream river flows. The in-water structures associated with the NDD construction will block or impede access to critical habitat, preventing migration by adult delta smelt from the downstream-most diversion near Clarksburg to the northern limit of delta smelt critical habitat. Construction cofferdams and the subsequent three NDD intakes and fish screen structures, ranging from 1,497 to 1,969 ft in length, will block, delay, or impede adult fish migration.

Conceptually, delta smelt migrate upstream, using the flood tide and use areas of hydrologic refuge (near the bottom or shoreline) to maintain its position in the estuary during the ebb tide. In the Sacramento River above Georgiana Slough the tide no longer reverses the direction of water flow but slows river velocity. In the Sacramento River above Georgiana Slough, upstream spawning migration is physically more difficult due to the lack of tidal excursion and higher spring river discharge, and thus fewer delta smelt disperse above this location than other areas of the estuary.

Delta smelt ascending the river cannot swim against mid-channel velocities for an extended time and thus critical habitat must provide low velocity paths to facilitate upstream migration along the Sacramento River while also providing cover to avoid predation (CWF BA 2016). In downstream locations vertical and lateral smelt distribution changes have been observed (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015), but these previous studies provide no evidence that delta smelt show affinity to one side of the river or the other when they move on and off shore.

Once constructed, each of the NDD intakes form a vertical wall extending laterally for 1,030-1,404 ft along the east bank of the Sacramento River and extending into the river channel (Figure 9.2.3.3.4-11). If adult delta smelt attempt to ascend the east bank of the river, they will no longer have contiguous shoreline and will need to swim against in-channel velocities if they attempt to pass the screens. By virtue of small body size, delta smelt are relatively "poor" swimmers (Swanson *et al.* 1998). In addition, they are non-continuous swimmers.

For a delta smelt to swim upstream at all, the river velocity has to be less than its sustainable swimming speed. If the river velocity is higher than the sustainable swimming speed and delta smelt cannot escape the current, then they will be pushed back downstream. Based on the observed swimming speed of delta smelt in treadmill studies (Swanson *et al.* 1998; Young *et al.* 2010), the NDD fish screen sweeping velocities, and the length of each NDD screen, the available evidence indicates that a delta smelt would seldom be able to migrate up the east side of the river past a single screen, let alone the length of all three screens, to access the Sacramento River above Clarksburg.

It is also unlikely that delta smelt could exclusively use the west bank to migrate past the NDD. The Sacramento River makes 6 major bends between Isleton and Freeport shunting the highest velocity parts of the river cross section back and forth across the channel, requiring fish to change banks to avoid being swept downstream. In addition to this shifting high velocity water, it seems unlikely that delta smelt could keep swimming up one bank of the river from Isleton to areas upstream because they would eventually need to avoid a predator or be displaced off the shoreline at night when they lose visual reference and become less active. Both of these phenomena would tend to mix migrating smelt across the shorelines from day to day.

Based on observed delta smelt swimming performance, screen length, screen sweeping velocities, and river water velocities during the spring spawning period, it is likely that the NDD in-water structures will delay, impede, or block upstream adult spawning migration, inhibiting the ability of upstream critical habitat to provide for adult migration and spawning. Although not currently preferred by the majority of migrating adults, the elimination of habitat in the northern portion of the delta smelt critical habitat reduces the volume and complexity of available spawning habitat including cooler, freshwater which the species may need during drier years and extreme drought. As addressed in Guiding Principle 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*, compensatory mitigation in the form of spawning habitat improvements in the Sacramento River will be provided at a site or sites that will provide the most benefit for delta smelt critical habitat into the future. Mitigation in the form of spawning habitat creation or restoration in the Sacramento River from Isleton to Hood will minimize the loss of critical habitat from the construction footprint. Habitat mitigation in areas (*e.g.*, west Delta, central Delta, north Delta, Cache Slough) may also compensate for lost spawning habitat but will be less representative of the spawning habitat and its conservation value lost due to the NDD, which includes spawning substrate located in cold, freshwater during drought.

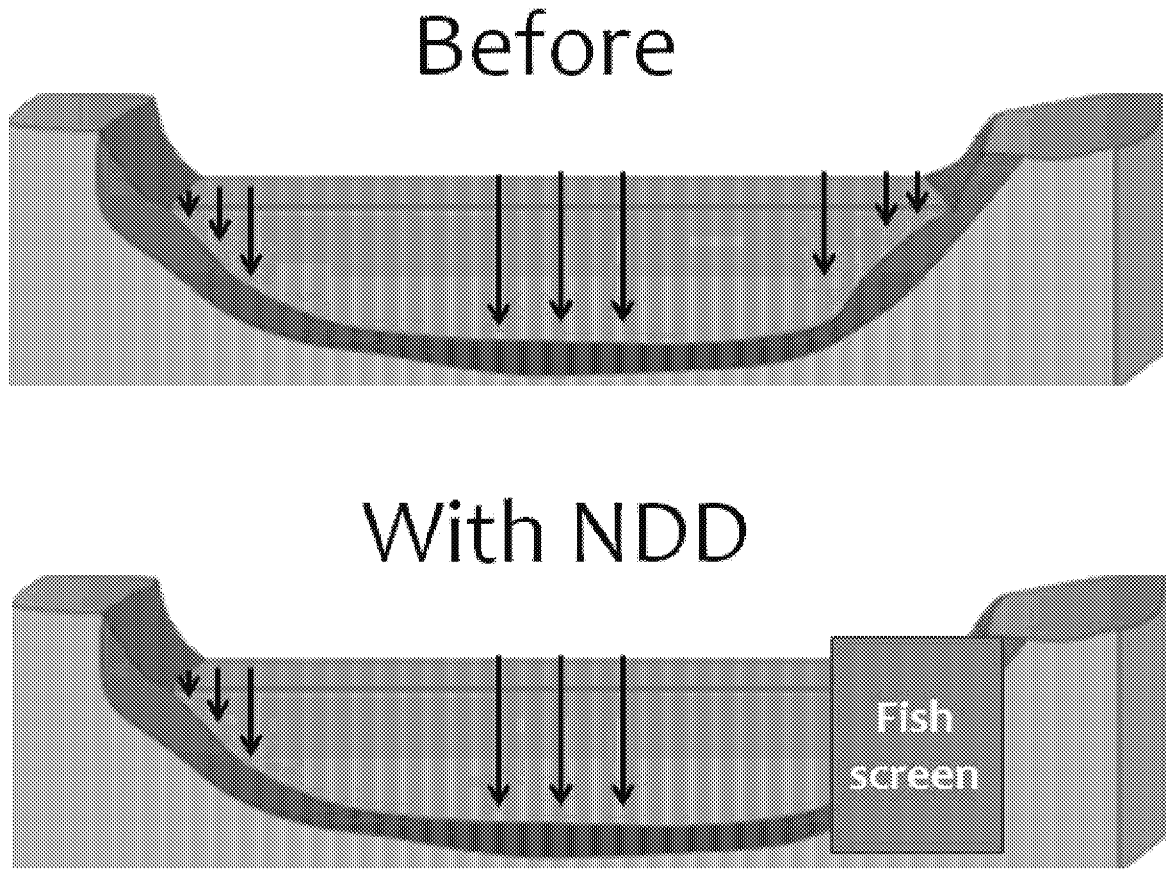

Figure 9.2.3.3.4-11. Demonstration of the low velocity stream margin habitat that will be removed by the NDD construction, intakes, and fish screens. Low velocity habitat is needed by delta smelt to migrate upstream in the Sacramento River above Isleton.

PCE 3 – River Flow

Adult delta smelt need unrestricted access to suitable spawning habitat from December to July. Adequate flow must be maintained to attract migrating adults in the Sacramento and San Joaquin River channels, and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during spawning migration.

Freshwater flows in combination with increasing turbidity are cues for adult delta smelt to migrate to spawning habitat in December through March (Sommer *et al.* 2011). South Delta water exports alter critical habitat by drawing turbid Sacramento River water into the central and south Delta, encouraging the migration of adult delta smelt further south and east, making them and their offspring vulnerable to entrainment. However, the shift in exports from the CVP and SWP to the NDD during the migration period is expected to maintain or improve critical habitat function related to transport flow and decrease the risk of entrainment of adult delta smelt at the south Delta export facilities. For the south Delta, OMR flows more positive than -2000 cfs are expected to be protective of a high fraction of migrating adults because Sacramento River water flowing into the mainstem of the San Joaquin River is not being rapidly drawn into Old and Middle river under those conditions. In the potential operational scenario presented in the PA, OMR flows would be less negative for adult migration in all months except December, in which flows would be similar to the current projected baseline conditions (Figure 9.2.3.3.4-12). Under the operational scenario in the PA, during adult migration, flow conditions in critical habitat would be increased and would function appropriately to cue spawning, and would reduce entrainment risk in a larger portion of the San Joaquin River from Jersey Point to Prisoners Point.

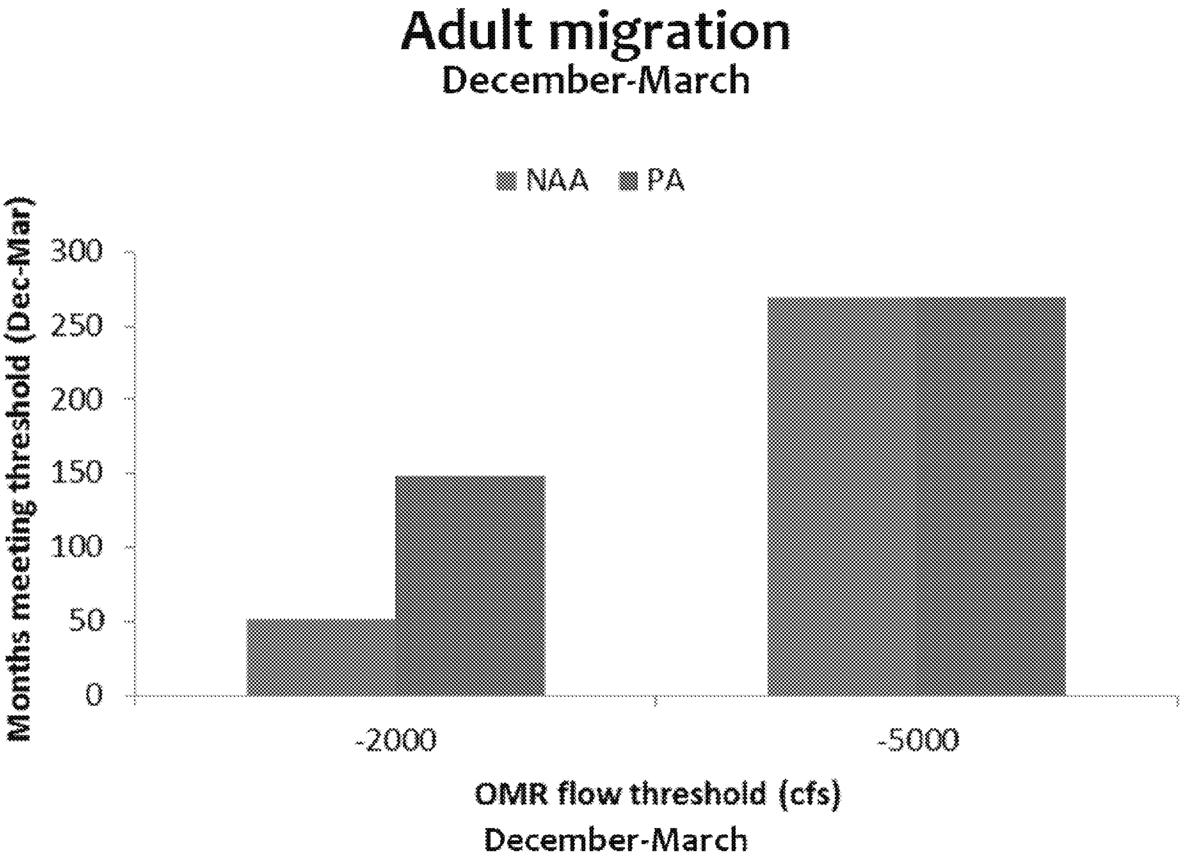

Figure 9.2.3.3.4-12. Comparison of the frequency of months that the NAA and PA were modeled to meet two OMR flow thresholds during the delta smelt adult migration period (December-March). Each month was modeled 82 times for a potential maximum frequency of 82 months times a four month period or 328 on the y-axis.

Small reductions in Delta outflow are predicted during the migration period because total exports would increase. Sacramento River flows would be reduced by small proportions (3-24%) in all months, with the highest flow reductions occurring during the migration period. Flows in the San Joaquin River near Antioch would be reduced in December but increase from January through March. Increased flows in the San Joaquin River during spawning migration would encourage delta smelt to use the San Joaquin River for spawning. Increased outflow in the San Joaquin River would improve the access to spawning habitat and provide appropriate habitat conditions for adult spawning and migration.

During the months of December through June, additional protections may be implemented during RTO to protect pulses of out-migrating salmonids in the mainstem of the Sacramento River, which would result in a reduction in water exports at the NDD (refer to the revised May 5, 2017 *BiOp Resolution Log*). CalSim II and the subsequent step-down analyses were not modeled to capture these changes in future decisions because they are based on RTO which is based on fish presence, which is unknown at this time. During RTO, there is a potential for there to be a shift in exports between the CVP and SWP facilities (NDD and south Delta) that could increase south Delta water exports in such a way that would reduce freshwater flow for adult migrants. Subsequent consultations will occur as they relate to those CWF activities subject to future Federal approvals, such as the dual conveyance operations, in which Reclamation and DWR have committed to analyze and further address species effects from CWF operations at that time (refer to the *Consultation Approach* section of this BiOp). In addition, implementation of Guiding Principle 2, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, will ensure that as future development of CWF operational criteria occurs, in coordination with the CVP and SWP operations in the south Delta, minimization of entrainment of migrating adult delta smelt will be incorporated. This Guiding Principle should minimize adverse effects of CWF flows for migrating adults in delta smelt designated critical habitat.

9.2.3.4 Effects of the Aggregate Status of the Critical Habitat/Environmental Baseline, and Proposed Action on PCEs of Critical Habitat for Delta Smelt

The purpose of the aggregate analysis is to evaluate the combined status of critical habitat, the effects of the PA, and the cumulative effects of non-Federal activities to determine their combined effects to critical habitat, its PCEs, and their conservation function and value.

Summary of the Status and Environmental Baseline for Critical Habitat

As discussed in the Status of Critical Habitat section, the status of delta smelt critical habitat is poor, although the majority of PCEs are present at certain times in most locations (Table 9.2.3.4).

PCE 1 – Physical habitat
Dredging and shipping channel maintenance increase water depths and increase water supply demands needed to maintain the LSZ in Suisun Bay. Levees are covered in large riprap for erosion protection. Over time, both dredging and levee construction and maintenance may have reduced the availability of spawning habitat along channel margins in the Delta. Although altered, spawning habitat with water depth variation is suitable in Suisun Bay and the larger channels of Suisun Marsh, the lower Sacramento River to the I-Street Bridge (including Cache Slough) and the lower San Joaquin River to approximately the City of Stockton.

PCE 2 – Water quality
At the Cache Slough/Liberty Island complex and the upper Sacramento Deepwater Ship Channel, where food availability appears to be adequate, over-summer water temperatures are warm, increasing metabolic rates, and signs of contaminant damage have been observed, with urban or agricultural pesticide runoff being likely sources. Agricultural drainage and urban stormwater runoff result in the continual presence of low levels of herbicides, fungicides, and insecticides throughout critical habitat. Sediment loading from the Sacramento River watershed

continues to decline, reducing sediment load available for resuspension and the maintenance of a turbid environment, which likely reduces cover from predators and provides light scatter that larvae use to find prey. Although water temperatures are a little lower, food availability at the confluence of the Sacramento and San Joaquin rivers and downstream into Suisun Bay is limited in its ability to support rearing juveniles due to the removal of plankton by the invasive overbite clam. Water quality is appropriate in the lower Sacramento River downstream of Rio Vista and in Suisun Bay (Hammock *et al.* 2015).

PCE 3 – River flow

Increasing winter river flows, which serve as queues for adult dispersal prior to spawning (migrants), are appropriate in the Sacramento River and less frequently in the San Joaquin River. In summer, the LSZ has been located in the river channels away from the wind-driven turbidity and food resources found in the shallows of Suisun Bay and Suisun Marsh. The Delta, particularly since 2011, has seen a proliferation of non-native invasive aquatic vegetation as a consequence of reduced outflow associated with drought. Watershed sediment depletion, high summer inflows to the Delta that do not translate into high outflow, and invasive plants work together to increase water clarity and favor non-native predatory and competitor fishes (Moyle and Bennett 2008). Modifications to export operations by the 2008 Service BiOp RPA have resulted in improved larval and juvenile transport flows in the San Joaquin River via Old and Middle river flow, but there is still some entrainment risk to delta smelt adults, larvae, and juveniles.

PCE 4 – Salinity

Salinities are suitable for adult migration, spawning, and larval transport. For juvenile rearing however, water storage, upstream diversions, and in-Delta exports have contributed to a spatially restricted LSZ, which, in turn, has impacted the extent and quality of habitat. Currently, summer-fall salinities in Suisun Bay, Suisun Marsh, and Montezuma Slough are within delta smelt salinity tolerance during the juvenile rearing period (Komoroske *et al.* 2016). However, the delta smelt seldom occurs in the estuary at salinities that begin to cause it physiological stress. Thus, salinity increases linked to changes in Delta outflow tend to be associated with an eastward shift in the spatial distribution of the delta smelt population (Nobriga *et al.* 2008), presumably because salinities can increase beyond what is optimal for osmoregulation given available food resources (Komoroske *et al.* 2014; 2016).

Table 9.2.3.4 The baseline condition and effects of the PA for each delta smelt critical habitat PCE.

Primary Constituent Element	Migrating adults		Spawning adults	
	Baseline	PA	Baseline	PA
PCE 1: Physical habitat	N/A	N/A	Invasive aquatic plant encroachment, dredging altered depths and substrate, channels leveed and riprapped.	Migration impediment along Sacramento River, habitat loss from footprint.
PCE 2: Water [quality]	Degraded water quality including reduced turbidity, agricultural and urban pesticide and nutrient runoff.	No substantive effect.	Degraded water quality including reduced turbidity, agricultural and urban pesticide and nutrient runoff, warmer water shortening spawning season.	No substantive effect.
PCE 3: River flow	OMR flows create entrainment, risk reduced by OCAP RPA.	Improved SJR flows during winter migration, NDD restricts access above Clarksburg.	OMR flows create entrainment, risk reduced by OCAP RPA.	Reduced risk of entrainment in the lower San Joaquin River, OMR risk remains.
PCE 4: Salinity [LSZ]		No change in affect.		No change in effect.
Primary Constituent Element	**Dispersing larvae and juveniles**		**Rearing larvae and juveniles**	
	Baseline	**PA**	**Baseline**	**PA**
PCE 1: Physical habitat	N/A	N/A	Invasive aquatic plant encroachment, dredging altered depths and substrate, channels leveed and riprapped.	No change in effect on water depths.
PCE 2: Water [quality]	Reduced turbidity.	No substantive effect.	Degraded water quality including reduced turbidity, agricultural and urban pesticide and nutrient runoff	Potential small changes: turbidity reduction, increased selenium loading, increased in *Microcystis* bloom frequency.
PCE 3: River flow	OMR flows create entrainment, risk reduced by OCAP RPA.	SJR flows will improve larval/juvenile transport.	Outflow affects salinity and the extent of rearing habitat at the LSZ and Montezuma Slough.	Lower outflow will increase salinity, limit extent and suitability of rearing habitat at the LSZ and Montezuma Slough.
PCE 4: Salinity [LSZ]	NA	NA	LSZ located upstream away from food supply and turbidity.	Lower outflow will increase salinity and limit extent and suitability of western parts of critical habitat, LSZ located in higher in Estuary with degraded habitat extent and suitability.

Summary of the Proposed Action

The operational scenario described in the PA concurrently provides adverse and beneficial effects to delta smelt critical habitat (Table 9.2.3.1). The transfer of exports to the NDD will improve adult migration, and larval and juvenile transport flows in the San Joaquin River from Jersey Point to Prisoners Point, thus improving spawning habitat in this reach of the San Joaquin River by reducing entrainment risk for spawning delta smelt, larvae and juveniles. Improved adult migration and larvae and juvenile transport flows will be realized provided that salmonid pulse protections from December through June at the NDD do not result in increased CVP and SWP exports during those months. Several water quality factors will have small beneficial effects (food web), small negative changes that are negligible (selenium, *Microcystis*) or have no substantive effect when evaluated with the proposed Conservation Measures (sediment entrainment).

The PA will create an impediment on the Sacramento River within critical habitat and alter adult migration flows that will isolate delta smelt from 250.6 acres of spawning habitat. Critical habitat and its PCEs above Intake 2 (RM 41.1) will remain intact but inaccessible to delta smelt. As addressed in Guiding Principle 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*, compensatory mitigation in the form of spawning habitat improvements in the Sacramento River will be provided at a site(s) that will provide the most benefit for delta smelt critical habitat into the future. Mitigation in the form of spawning habitat creation or restoration in the Sacramento River from Isleton to Hood will minimize the effect of the loss of and access to critical habitat from the construction footprint.

The potential operational scenario presented in the PA would degrade salinity for juvenile rearing in July, August and September by moving X2 upstream as much as 5 km and restrict use of Montezuma Slough for juvenile rearing in all but wet and above normal years. Implementation of Guiding Principle 1, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, is intended to improve habitat conditions for rearing juvenile delta smelt, which may include locating the LSZ in suitable areas of the estuary, minimizing the adverse effects to delta smelt critical habitat. Future actions, including the development of the final operational criteria, will be designed and implemented to minimize the effects of critical habitat contraction created by the PA's operational scenario. Thus, the adverse effects of habitat contraction are anticipated to be minimized in any future operational scenario.

As discussed in Section 9.2.2.2.2 *Operational Uncertainties and the Collaborative Scientific Process* of this BiOp, the potential CWF operation scenario that has been analyzed in this document will change between now and when the dual conveyance system goes online. Reclamation and DWR have committed to implement future CWF actions consistent with Guiding Principles, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*, and those future actions will be subject to subsequent consultation. Implementation of the Guiding Principles will ensure that effects to delta smelt designated critical habitat from future CWF construction and operations will not appreciably diminish the value of critical habitat for the species.

Summary of Aggregate Effects

The operational scenario in the PA would improve larval and juvenile transport flows (PCE 3) for spawning adults, larvae and juveniles reducing entrainment risk in the San Joaquin River from Jersey Point to Prisoners Point. The operational scenario in the PA would also alter and contract suitable critical habitat, particularly spawning and rearing habitat, reducing the diversity and complexity of critical habitat.

The operational scenario described in the PA would result in (1) additional upstream excursion of X2 from already suboptimal locations of the LSZ in summer, further decoupling the LSZ from PCE 2 (food availability, turbidity, and salinity) for juvenile rearing, (2) further salinity intrusion from the west into Montezuma Slough that will not support rearing delta smelt in three out of five WY types (critically dry, dry, and normal), (3) improve transport flows (*i.e.*, reduced entrainment) for spawning migration, adult spawning and larval and juvenile transport in the lower San Joaquin River from Jersey Point to Prisoners Point, though OMR flows remain insufficient to prevent entrainment into the CVP and SWP, and (4) the NDD which blocks, delays, or impedes access of adult migrants to spawning habitat in the Sacramento River upstream of Clarksburg. The restriction of access to the Sacramento River above Clarksburg of spawning adults excludes delta smelt from the spawning habitat and water quality (cold, freshwater) that could have increasing conservation value due to sea level rise, reductions in precipitation in the northern Sacramento Valley, and increasing water temperatures associated with climate change.

The CWF operational scenario that has been analyzed in this document will change between now and when the dual conveyance system goes online. In the *Description of the Proposed Action*, Reclamation and DWR have committed to implement the Guiding Principles, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*, and further address effects for CWF operations in the context of subsequent consultations on CWF actions that will include the further development and refinement of the CWF operational criteria. Implementation of the Guiding Principles, and other conservation efforts, will ensure that critical habitat for all life stages will continue to serve its intended conservation role for the species. Based on these commitments, we understand that many of the effects discussed in this BiOp may or may not be realized when CWF is implemented.

Our analysis outlines threats to delta smelt now and in the future - most of which exist with or without implementation of the PA. Primary threats to delta smelt include habitat loss and degradation, food web alterations (including increased predator and competition presence and food supply reduction), and persistent exposure to contaminants. Many of these threats are being addressed on a broader scale in the near term. The State and Federal agencies have several ongoing actions that are intended to address multiple threats to delta smelt, including the State Board's update of the WQCP for the Bay-Delta, the reinitiation of the 2008 Service BiOp and

2009 NMFS BiOp on the long-term operation of the CVP and SWP, California EcoRestore, the Delta Smelt Resiliency Strategy and the update of the recovery plan for delta and longfin smelt. These and other ongoing efforts will help to reduce existing threats to delta smelt.

As discussed in the *Status of Critical Habitat* section, the status of designated delta smelt critical habitat is poor. At least one PCE is always lacking or degraded throughout critical habitat year-round (Table 9.2.1.3-2). The analysis of the effects of the PA on critical habitat found two elements of the PA that will alter delta smelt critical habitat PCEs: 1) block, delay, or impede adult migration on the Sacramento River and 2) a modeled summer outflow regime that reduces LSZ habitat quality. With respect to changes in the location of the LSZ from July through September, implementation of the Guiding Principles as the framework for future CWF consultations, reinitiation of the 2008 Service and 2009 NMFS BiOps on the long-term operation of the CVP and SWP, and other conservation efforts described above, will ensure that juvenile rearing habitat continues to serve its intended conservation role for the species. We expect the CWF AMP to inform the mitigation to minimize effects to critical habitat for adult migrating delta smelt.

9.2.4 Project-level Reinitiation Triggers and Programmatic Approach with Subsequent Consultation

This BiOp uses a programmatic approach to evaluate the elements of the PA that will be subject to future project-specific consultations because of the need for future Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts to delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the action area. The remainder of the project elements not addressed programmatically are addressed as a standard, project-level consultation because they are not subject to future Federal approvals. Some project elements and their effects on delta smelt or its critical habitat will change as DWR continues to develop the PA and therefore may require reinitiation for those actions evaluated at a project-level if there are effects to listed species or critical habitat that were not analyzed herein.

Accidental Spills

The extent, location, quantity, and nature of an accidental spill is unknown at this time until the event of the spill occurs. Implementation of CWF BA Appendix 3.F, *General Avoidance and Minimization Measures,* AMM5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14, *Hazardous Materials Management*, is expected to reduce the potential for contaminant spills and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (*e.g.*, AMM3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to the river from in-water or upland sources will be minimized. However, reinitiation may be required if habitat is affected or individuals will be exposed to contamination from an accidental spill.

Preconstruction and Construction

Geotechnical Explorations

The location or duration of the geotechnical explorations and their effects on delta smelt or its critical habitat will likely change as the PA is refined. Therefore, reinitiation is required if additional habitat is affected or more individuals will be exposed based on changes in proposed locations of the borings.

Barge Landings

The barge landing locations analyzed in this BiOp represent the general areas for these facilities. Some of the locations and their effects on delta smelt or its critical habitat will likely change as DWR continues to develop the PA and therefore may require reinitiation for those actions. DWR has provided estimates of habitat acreages in the CWF BA that are anticipated to be removed, altered, or degraded from barge landing construction, in the form of shallow water habitat, which encompasses all edgewater substrates including sandy beaches. GIS estimates of the shallow water habitat for the seven barge landing locations were calculated for the CWF BA; however, DWR will ground truth all habitat prior to impact. If the amount of habitat or level of exposure to the effects of the barge landings changes as a result of refinement of the barge landing locations, reinitiation may be required.

This BiOp analyzes a reasonable set of estimates of underwater noise and sediment disturbance effects that are expected to occur from impact pile driving equipment and other methods of cofferdam installation and foundation construction associated with the barge landings based on previous projects that have occurred. However, during implementation, DWR will monitor noise and sediment levels created by heavy construction equipment. If the duration or location of underwater noise or turbidity thresholds extend or peak higher than those analyzed herein, DWR and the action agencies will confer with the Service to determine if project modifications are necessary, and reinitiation may be necessary if additional adverse effects are found to be likely to delta smelt or critical habitat.

NDD

Within this document, NDD construction has been analyzed at a programmatic-level. All in-water work associated with construction of the NDD will require a permit during Phase 2 of the Corps permitting process and additional consultation under section 7 of the Act. DWR will refine estimates of habitat effects and incidental take, and propose compensation consistent with the conservation measures described in the CWF BA Chapter 3, *Description of the Proposed Action*, in association with these future permits.

It is assumed that once the intakes are completed, the area in front of each intake will be dredged to provide appropriate water depths and hydraulic conditions. If dredging is required, DWR has proposed to minimize effects to delta smelt by conducting maintenance activities within the in-water work window of June 1 through October 31, when delta smelt are least likely to occur in vicinity. It is also assumed that periodic maintenance dredging will be needed to maintain appropriate flow conditions and will occur as described in the CWF BA Chapter 3, *Description of the Proposed Action*, and subsequent additional information that has been provided to the Service since submitting the CWF BA. NDD maintenance is also described programmatically herein and associated with Phase 2 of the Corps permitting process; therefore, subsequent consultation with the Service will occur, when additional details on maintenance are available associated with a final NDD design.

CWF BA page 6-22 clarifies that no barge landings are estimated to be constructed along the Sacramento River in the vicinity of the NDD. This was substantiated in subsequent meetings and emails after the CWF BA submittal. Therefore, those calculations are not included in this analysis. If during the course of refining the NDD, there are additional effects not analyzed herein to delta smelt from the need for more than the seven analyzed barge landings, reinitiation will be necessary.

This BiOp analyzes a reasonable set of estimates of underwater noise and sediment disturbance effects that is expected to occur from impact pile driving equipment and other methods of cofferdam installation and foundation construction associated with the NDD based on previous projects that have occurred. However, during implementation, DWR will monitor noise and sediment levels created by their heavy construction equipment. If the duration or location of underwater noise or turbidity thresholds extend or peak higher than those analyzed herein, DWR and the action agencies will confer with the Service to determine if project modifications are necessary, and reinitiation may be necessary if additional adverse effects are found to be likely to delta smelt or critical habitat.

DWR has provided estimates of habitat acreages in the CWF BA that are anticipated to be removed, altered, or restricted from proposed NDD construction activities. Aerial imagery was used to determine these habitat acreages based on the best imagery available at the time of this consultation. DWR will inspect all habitats prior to the impact to confirm the estimates in the PA. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation on Phase 2 of the Corps permitting process when more information on the final siting and design of the NDD is available. As currently provided, the CWF BA does not quantify the amount of sandy substrate within the shallow water habitat footprint. The area of habitat lost to upstream access is estimated through aerial imagery (an estimate was feasible due to low vegetation in the area covering the substrate) that is expected to be refined when additional information is made available, prior to impact. A future Service-approved monitoring plan is proposed to be developed and could provide details on the monitoring efforts that will be conducted to assess restricted upstream passage from NDD construction and operation.

<u>HORG</u>

Within this document, HORG construction has been analyzed at a programmatic-level. The CWF BA provides estimates of shallow water habitat that is anticipated to be removed, altered, and/or degraded from the proposed construction activities. GIS (geographic information system) spatial data provided by DWR were used to determine these habitat acreages. However, DWR will inspect all potential habitat prior to impact to confirm the estimates provided in the CWF BA, consistent with how the Service has defined shallow water habitat. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation on Phase 2 of the Corps permitting process when more information is available on the final siting and design of the HORG.

CCF Forebay Construction, CCF Pumping Plant Construction, and Connections to Banks and Jones Pumping Plants

A future Service-approved monitoring plan is proposed to be developed and could provide details on the monitoring efforts that will be conducted to assess potential changes in salvage estimates from existing CVP and SWP operations of the pumping facilities. Monitoring will inform the refinement of effects in the CCF from construction on salvage. Reinitiation may be necessary if salvage estimates are modified from implementation of the PA or if additional adverse effects are found to be likely to delta smelt or critical habitat beyond what has been analyzed in this BiOp and the 2008 Service BiOp.

Operations

Agency decisions related to identifying the final CWF operational criteria will be made in a subsequent consultation, and Reclamation and DWR have committed to analyze and further address species effects from CWF operations at that time. The Guiding Principles in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation* establish a framework in this consultation under which the future CWF actions will be developed to ensure both that future consultations related to CWF actions build upon the analysis in this document and that the CWF is constructed and operated in a manner that promotes the co-equal goals articulated in California's Delta Reform Act. These Guiding Principles are subject to change over time where the best available scientific information indicates that such change is appropriate. In such event, the agencies will evaluate whether the change triggers the requirement to reinitiate consultation.

NDD

Operational criteria have been identified in the *Description of the Proposed Action* for the NDD, such as approach and sweeping velocity; however, there has not been a final design of the NDD facility. The intake design will be developed in coordination with the Service, NMFS, and CDFW during the continued FFTT identified in the CWF BA. The FFTT will further refine the monitoring, research, operational criteria, and other efforts necessary for a 100% design required for the Corps' 408 process and fall under review during the *Adaptive Management Program*. Reinitiation may be required if effects to listed species rise above those analyzed herein for the construction footprint or other project-level components addressed in this consultation. The FFTT will pursue ways to further minimize effects to delta smelt and other federally-listed species that may not necessarily be defined in this BiOp. This BiOp uses a programmatic approach to evaluate the proposed operations in the PA that will be subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of delta smelt occurring in the action area. As discussed above under *Operational Uncertainties and the Collaborative Scientific Process*, the CWF operational scenario that has been analyzed above will change between now and when the dual conveyance system goes online. Reclamation and DWR have committed to analyze and further address species effects from CWF operations at the time of the subsequent consultations within the framework of the Guiding Principles outlined in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*. Reclamation and DWR have also committed to propose future actions that will avoid jeopardizing the delta smelt and destroying or adversely modifying its critical habitat. Those future actions could include: new or modified operational criteria, minimizing project footprints during the final design phase, conservation efforts to maintain or increase trends in delta smelt abundance, efforts to restore and/or improve habitat conditions that support delta smelt, and other actions to be defined in the future. These future actions will be informed by the State Board process, reinitiation of the 2008 Service BiOp, the *Adaptive Management Program*, and other State and Federal processes.

<u>South Delta Water Facilities</u>

Operational criteria have been identified in the *Description of the Proposed Action* for the existing south Delta water facilities, such as those requirements identified in the RPA of the 2008 Service BiOp governing OMR flows and fall X2 location. However, Reclamation and DWR will likely modify existing (and future dual conveyance) operations. As discussed above, this BiOp uses a programmatic approach to evaluate the proposed operations in the PA that will be subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on listed species and their designated critical habitats, and examines how the parameters of the CWF align with the survival and recovery needs of delta smelt occurring in the action area.

<u>HORG</u>

Assumptions have been made on how the HORG will be operated for modeling purposes; however, the HORG operational criteria will be managed in real-time and be considered in future consultations related to subsequent Federal approvals. The gate design will be developed in coordination with the Service, NMFS, and CDFW during the technical team process identified in the CWF BA. The technical team will further refine the monitoring, research, operational criteria, and other efforts necessary for a 100% design required for the Corps' 408 process and fall under review during the *Adaptive Management Program*. The technical team will pursue ways to further minimize effects to delta smelt and other federally-listed species that may not necessarily be defined in this BiOp. This BiOp uses a programmatic approach to evaluate the proposed operations in the PA that will be subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the action area.

<u>DCC, Suisun Marsh Facilities, NBA Intake, and Other Facilities</u>

This BiOp uses a programmatic approach to evaluate the proposed operations in the PA that will be the subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the action area.

9.2.5 Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this BiOp. Future Federal actions that are unrelated to the proposed project are not considered in this section; they require separate consultation pursuant to Section 7 of the Act.

Major human interactions and uses of the landscape within the action area include: agricultural practices; recreational uses; urbanization and industrialism - commercial and private; and greenhouse gas emissions.

Agriculture

Farming occurs throughout the Delta adjacent to many waterways used by delta smelt. Levees are reinforced with continual vegetation removal and riprapping to stabilize the levees and protect the land behind the levees for agricultural purposes. Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman *et al.* 2014); however, wastewater treatment provides the bulk of ammonium loading, for example (Jassby 2008). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect delta smelt reproductive success and survival rates (Dubrovsky *et al.*1998; Kuivila *et al.* 2004; Scholz *et al.* 2012). Discharges occurring outside the action area that flow into the action area also contribute to cumulative effects of contaminant exposure.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the action area, and many of them remain unscreened. Most diversions of any substantial size and cost have been screened, such as new municipal water diversions, and are routinely screened per existing BiOps. Private irrigation diversions in the Delta are mostly unscreened, but the total amount of water diverted onto Delta farms has remained stable for decades (Culberson *et al.* 2008) so the cumulative impact should remain similar to baseline. Irrigated agriculture is anticipated to continue into the future, especially for permanent crops that rely on Delta water as a controlled water source for growth. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain many life stages of aquatic species, including delta smelt. However, the vast majority of private unscreened diversions in the action area are small pipes in large channels that operate intermittently, and mainly during the spring and summer. As a result, even where they do regularly co-occur with these diversions, delta smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004). Nobriga *et al.* (2004) reasoned that the littoral location and small size of these diversions reduced their risk of entraining delta smelt.

Urbanization and Industrialism

The Delta Protection Commission's Economic Sustainability Plan for the Delta reported an urban growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the State as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 (California Department of Finance 2012). Table 9.2.5-1 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 9.2.5-1. Delta counties and California population, 2000–2050.

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01
Sources: California Department of Finance 2012.					

Table 9.2.5-2 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities

having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 9.2.5-2. Delta communities population, 2000 and 2010.

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%

Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			
Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%
Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.			
[a] Freeport had a population of 38; Hood had a population of 271.			

Increases in urbanization and housing development can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require consultation with the Service. State or local levee maintenance may also destroy or adversely affect delta smelt spawning or rearing habitat and interfere with natural, long-term spawning habitat-maintaining processes. Adverse effects on delta smelt and its critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, pharmaceuticals, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into Delta waterways from shipping and boating activities and from urban activities and runoff. Implicated as potential stressors to delta smelt, these contaminants may adversely affect delta smelt reproductive success, survival rates, and food supply.

Contaminants are suspected to be a stressor on delta smelt (Kuivila and Moon 2004; Brooks *et al.* 2012). A study of juvenile delta smelt in five regions encompassing their range examined delta smelt for signs of contaminants and food limitation. The histopathological analysis of the 244 fish sampled in 2012 and 2013 found an 11-fold increase in gill and liver lesion scores in Cache Slough as compared to Suisun Marsh. Higher lesion scores indicate less healthy tissues and are indicative of contaminant-related stress (Hammock *et al.* 2015).

The largest urban discharger to the Delta is the Sacramento Regional Wastewater Treatment Plant (SRWTP). In order to comply with Central Valley Regional Water Quality Control Board Order no. R5-2013-0124, SRWTP has begun implementing compliance measures to reduce its discharge of ammonia and ammonium. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order No. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board, imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L total ammonia nitrogen) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day. A study by Werner *et al.* (2008) concluded that ammonia concentrations present in the Sacramento River below the SRWTP are not acutely toxic to 55-day-old delta smelt. However, based on information provided by EPA (1999) and other related studies, it is possible that concentrations below the SRWTP may be chronically toxic to delta smelt and other sensitive fish species (Werner *et al.* 2010). In 2010, the same group conducted three exposure experiments to measure the effect concentration of SRWTP effluent. No significant effects of effluent on the survival of larval delta smelt were found. More recent studies (which used concentrations of ammonia higher than typically experienced by delta smelt) have shown that delta smelt that are exposed to ammonia exhibit membrane destabilization. This results in increased membrane permeability and increased susceptibility to synergistic effects of multi-contaminant exposures (Connon *et al.* 2009; Hasenbein *et al.* 2014). Results are unclear at this time as to what the effect of ammonia exposure is on delta smelt, and research is ongoing. EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Studies are ongoing to further determine the adverse effects of ammonia on delta smelt.

In addition to concerns about direct toxicity of ammonia to delta smelt, another important concern is that ammonium inputs have suppressed diatom blooms in the Delta and Suisun Bay, thereby reducing the productivity in the delta smelt food web. The IEP (2015) provided the following summary: "Dugdale *et al.* (2007) and Wilkerson *et al.* (2006) found that high ammonium concentrations prevented the formation of diatom blooms but stimulated flagellate blooms in the lower estuary. They propose that this occurs because diatoms preferentially utilize ammonium in their physiological processes even though it is used less efficiently and at high concentrations ammonium can prevent uptake of nitrate (Dugdale *et al.* 2007). Thus, diatom populations must consume available ammonium before nitrate, which supports higher growth rates, can be utilized or concentrations of ammonium need to be diluted. A recent independent review panel (Reed *et al.* 2014) found that there is good evidence for preferential uptake of ammonium and sequential uptake of first ammonium and then nitrate, but that a large amount of uncertainty remains regarding the growth rates on ammonium relative to nitrate and the role of ammonium in suppressing spring blooms." The IEP (2015) further discussed this issue as follows: "Glibert (2011) analyzed long-term data (from 1975 or 1979 to 2006 depending on the variable considered) from the Delta and Suisun Bay and related changing forms and ratios of nutrients, particularly changes in ammonium, to declines in diatoms and increases in flagellates and cyanobacteria. Similar shifts in species composition were noted by Brown (2009), with loss of diatom species, such as *Thalassiosira* sp., an important food for calanoid copepods, including *Eurytemora affinis* and *Sinocalanus doerri* (Orsi 1995). More recently, Parker *et al.* (2012) found that the region where blooms are suppressed extends upstream into the Sacramento River to the SRWTP, the source of the majority of the ammonium in the river (Jassby 2008). Parker *et al.* (2012) found that at high ambient ammonium concentrations, river phytoplankton cannot efficiently take up any form of nitrogen including ammonium, leading to often extremely low biomass in the river. A study using multiple stable isotope tracers (Lehman *et al.* 2014) found that the cyanobacterium *M. aeruginosa* utilized ammonium, not nitrate, as the primary source of nitrogen in the central and western Delta. In 2009, the ammonia concentration in effluent from SRWTP was reduced by approximately 10%, due to changes in operation (K. Ohlinger, Sacramento Regional County Sanitation District, personal communication). In spring 2010, unusually strong spring diatom blooms were observed in Suisun Bay that co-occurred with low ammonia concentrations (Dugdale *et al.* 2013).

Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the estuary frequented by delta smelt and its recent upgrades suggest it is not a significant concern for delta smelt.

Other future, non-Federal actions within the action area that are likely to occur and may adversely affect delta smelt and their critical habitat include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; and State or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long-term habitat-maintaining processes.

Recreational Uses

Increased urbanization is also expected to result in increased recreational activities in the action area. Recreational activities, such as the construction and maintenance of golf courses reduce habitat and introduce pesticides and herbicides into the aquatic environment. The Delta, Yolo Bypass, and Suisun Marsh contain numerous parks, extensive public lands, and many interconnected rivers, sloughs, and other waterways that offer diverse recreation opportunities. Privately owned commercial marinas and resorts allow for boating access to the waterways and a variety of other recreational opportunities and services. Private lands also provide several recreational opportunities, particularly hunting.

The Delta is a regional destination for water-based recreationists because of its climatic conditions, variety and abundance of fish, large maze of navigable waterways, and favorable water levels during summer when most regional reservoirs experience substantial drawdown. Activities in the Delta include cruising, waterskiing, wakeboarding, using personal watercraft, sailing, windsurfing, and kiteboarding, as well as fishing and hunting (from land and by boat). Non-powered boating activities in the Delta include sailing, windsurfing, kiteboarding, canoeing, and kayaking.

Hunting has long been a recreational activity in the Delta, with waterfowl hunting being the primary type. Hunting by boat (typically used as a floating blind) is popular at the larger flooded islands, such as Franks Tract and Sherman Island, because hunters seek open, shallow waters and marsh areas where waterfowl congregate (California Department of Boating and Waterways 2003). Licenses and duck stamps to hunt waterfowl are required by the CDFW and the Service. CDFW manages hunting in California, including the public hunting programs at Sherman Island and other smaller wildlife areas. The California Department of Parks and Recreation allow hunting at Franks Tract, designated as Franks Tract State Recreation Area. Boat hunting is also allowed at Big Break, which is managed by the East Bay Regional Park District (Delta

Protection Commission 1997). Late fall through early winter is the designated waterfowl hunting season; starting and ending dates vary each year by species and by hunting method.

Suisun Marsh has historically been a popular duck hunting location; around 1880, the first private duck clubs were established in the marsh, and by 1930, the primary use of Suisun Marsh was waterfowl hunting (DWR 2000). Duck hunting continues to be a use of Suisun Marsh, with 158 private duck clubs located over 52,000 acres in the marsh. These clubs are managed for waterfowl habitat; the wetlands are flooded to coincide with waterfowl season (DWR 2009a, 2011).

Most of the 370 water diversions operating in Suisun Marsh supply water to waterfowl hunting clubs and are unscreened (Herren and Kawasaki 2001). However, the SWP's Roaring River and MIDS diverts most of the water into the marsh. Water is subsequently redistributed further by the many smaller diversions. Roaring River is screened while Morrow Island is not; however, delta smelt entrainment into the MIDS is low due to high salinity in western Suisun Marsh (Enos *et al.* 2007).

Greenhouse Gas Emissions

There is an international scientific consensus that most of the warming observed has been caused by human activities (IPCC 2001; IPCC 2007a; IPCC. 2007b), and that it is "very likely" that it is largely due to man-made emissions of carbon dioxide and other greenhouse gases in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007b; Solomon *et al.* 2009). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities. Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al.* 20092009; IPCC 2014).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007; Ganguly *et al.* 2009). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl *et al.* 2007; Ganguly *et al.* 2009; IPCC 2014).

Ongoing climate change (lnkley *et al.* 2004; IPCC 2007a, b) will likely adversely affect delta smelt, since climate change will likely result in sea level changes and overall wet and dry cycles, it may result in changes to availability and distribution of habitat and prey, and/or increase numbers of predators, parasites, diseases, and non-native competitors. For the endemic delta smelt, a changing climate may result in range shifts precluded by lack of habitat. For additional information on climate change as it relates to delta smelt, see *Status of the Species*.

Summary of the Cumulative Effects to Delta Smelt

Cumulative effects to delta smelt within the action area include: agricultural practices; recreational uses; urbanization and industrialism - commercial and private; and greenhouse gas emissions. Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the action area, and many of them remain unscreened. Most diversions of any substantial size are routinely screened through consultation with the Service. Private irrigation diversions in the Delta are mostly unscreened; however, the vast majority of private unscreened diversions in the action area are small pipes in large channels that operate intermittently, and mainly during the spring and summer. As a result, even where they do regularly co-occur with these diversions, delta smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004).

With the projected growth rate of 1.2% annually through 2030, we can expect to observe future increases in urbanization and housing developments that may ultimately lead to adverse effects to delta smelt spawning or rearing habitat and interfere with natural, long-term spawning habitat-maintaining processes (California Department of Finance 2012).

Delta smelt's exposure to contaminants are inherent in the Delta, ranging in degree of effects. Sources of introduction vary from agricultural use pesticide runoff to urban wastewater treatment discharge, and other potential sources. Implicated as potential stressors to delta smelt, these contaminants may adversely affect delta smelt reproductive success, survival rates, and food supply.

Greenhouse gas emissions leading to climate change and sea-level rise are likely already effecting delta smelt and its habitat. Ongoing climate change as a result of human activities likely imperils delta smelt and the resources necessary for its survival, since climate change threatens to disrupt annual weather patterns, affecting availability and distribution of habitats and/or food base, and/or increase numbers of predators, parasites, diseases, and non-native competitors. In an isolated population such as that of the delta smelt, a changing climate may result in local extinction, with range shifts precluded by lack of habitat.

Summary of the Cumulative Effects to Critical Habitat

Agriculture, urbanization and climate change are most likely to affect critical habitat. PCE 2 (Water Quality) impairment is likely to continue or increase due to agriculture irrigation and municipal waste water discharge which introduces nutrients and pesticides into the watershed.

Water temperatures, influenced by warming air temperatures from climate change, are expected to rise. Delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the Pacific Coast of North America and is living in an environment that is energetically stressful. Thus, increased water temperatures associated with climate change may present a significant conservation challenge. PCE 3 (River flow) reductions and the associated PCE 4 (Salinity) intrusion will increase as human population growth places additional demands on water resources and less freshwater will available to maintain the LSZ at a suitable location particularly for juvenile rearing habitat. Climate change will also alter the timing and form of precipitation (rain or snow) in the watershed depending on latitude. Sea level rise will likely influence saltwater intrusion into the Bay-Delta. Elevated salinity could push X2 farther up the estuary with mean values increasing by about 7 km by 2100 (Brown *et al.* 2013). The status of critical habitat (PCEs 2, 3, and 4) will likely be degraded by each of these cumulative effects in the early long-term.

9.2.5 Conclusion

9.2.6.1 Delta Smelt

In conclusion, after reviewing the current status of the delta smelt, environmental baseline, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the preconstruction, construction, and operations of the new and existing CVP and SWP water facilities, as proposed, are not likely to jeopardize the continued existence of the delta smelt. The Service has reached this conclusion based the information presented in the preceding *Status of the Species*, *Environmental Baseline*, *Effects to Delta Smelt from the Proposed Action*, and *Cumulative Effects* sections of this BiOp.

9.2.6.2 Delta Smelt Critical Habitat

In conclusion, after reviewing the current status of delta smelt critical habitat, environmental baseline, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the preconstruction, construction, and operations of the new and existing CVP and SWP water facilities, as proposed, are not likely to destroy or adversely modify delta smelt critical habitat. The Service has reached this conclusion based the information presented in the preceding *Status of the Critical Habitat, Environmental Baseline*, *Effects to Delta Smelt Critical Habitat from the Proposed Action*, and *Cumulative Effects* sections of this BiOp.

Section 9.2.7 Delta Smelt Literature Cited

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